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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
H03K 7/10, 9/10, H04B 14/02, H04J 9/00 | **A1**

(11) International Publication Number: **WO 98/28847**

(43) International Publication Date: 2 July 1998 (02.07.98)

(21) International Application Number: PCT/DK97/00592

(22) International Filing Date: 22 December 1997 (22.12.97)

(30) Priority Data:
1505/96 23 December 1996 (23.12.96) DK

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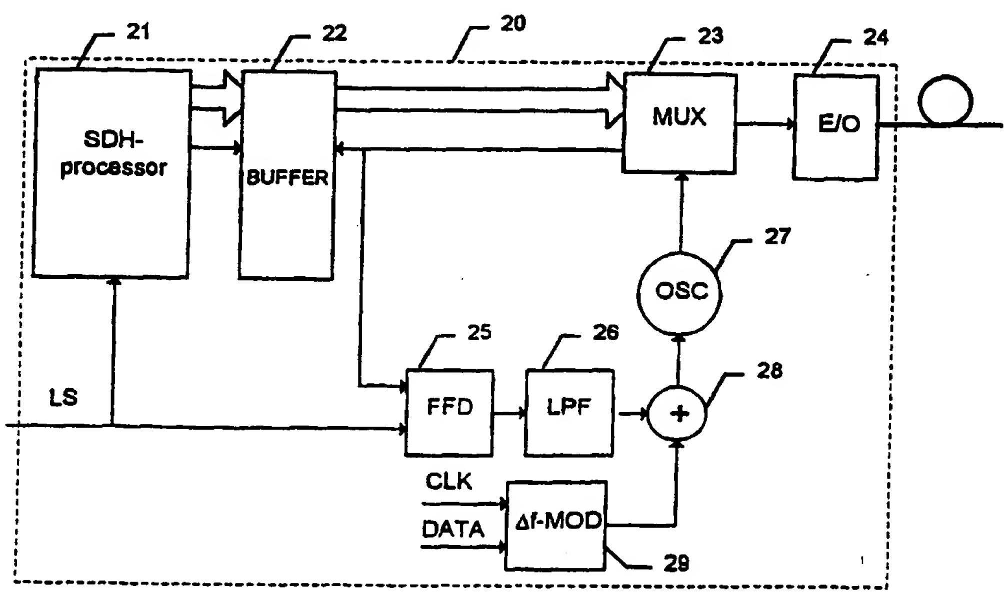
(81) Designated States: AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: A METHOD AND A CIRCUIT FOR THE TRANSFER OF DATA INFORMATION



(57) Abstract

A method of transferring relatively low frequency data information on a data channel for relatively high frequency data transmission comprises modulating the data rate of the relatively high frequency data channel in accordance with the low frequency data information. The phase variation generated thereby is controlled so as to be within a range which is defined upwardly by a predetermined value and defined downwardly by the phase variation which occurs in the data channel at an unmodulated data rate. This ensures that additional data information may be transferred in a network in which a determined phase variation (jitter) requirement (34, fig. 5) is to be observed. A circuit in the form of a buffer (22) and a multiplexer (23) controlled by a phase–locked loop (25, 26, 27) to restrict phase variations (jitter) out of a transmitter (20) additionally comprises a circuit (29) so that the multiplexer (23) depends on a signal (DATA).

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A method and a circuit for the transfer of data information

The invention relates to a method of transferring relatively low frequency data information on a data channel for relatively high frequency data transmission. This may e.g. comprise transfer of control and monitoring signals on a channel intended for telecommunication.

In many forms of communications networks it is necessary to have a facility for controlling and monitoring the network. In connection with this control and monitoring it is expedient to have a special channel which is dedicated to the purpose. This channel may be implemented in may ways, but, of course, the implementation must be based on the technology which works best together with the communications network both technically and economically.

Communications networks in which data are transmitted at high rates frequently work with a complex and standardized frame structure in which the data to be transmitted on the network are arranged. This frame structure allows embedding of a certain amount of information which is related to the control and monitoring of the communications network together with the data which the network is intended to transmit. It is hereby made possible for the network elements capable of inserting communications signals into and extracting them from this frame structure to communicate with each other about the state of the network.

An example of a communications network in which data are transmitted at high rates is optical telecommunications networks. In optical telecommunications networks which

extend over relatively great distances and in which the network elements are interconnected by optical fibres, it is possible to use purely optical amplifiers between the network elements to compensate for attenuation through the optical fibres. It is desirable to be able to control these purely optical amplifiers, without it being necessary to implement expensive and sophisticated electronics in order to extract the control and monitoring signals which are embedded in the mentioned frame structure.

The prior art includes systems in which control and monitoring signals may be transmitted on the same physical medium as the data transmission signals, without it being necessary to extract the control and monitoring signals which are embedded in the frame structure.

A known method of transferring the mentioned control and monitoring signals in e.g. an optical communications system is based on transmission of the data communications signals at one nominal wavelength through the optical fibre and transmission of the control and monitoring signals at another nominal wavelength. This prior art, however, is vitiated by the drawback that additional bandwidth is occupied in the fibre in the form of a frequency band around the said another nominal wavelength. Further, this technique requires more expensive wavelength multiplex components and selected lasers.

Another known method of transferring control and monitoring signals in both optical and traditional electrical communications systems is based on a relatively low frequency amplitude modulation of the data transmission signals. This method occupies additional wavelength only to a very limited extent, but, on the other hand, it impairs the sensitivity of a receiver when the data transmission

signals in the form of electrical pulses are to be regenerated.

Accordingly, an object of the invention is to provide a method of transferring control and monitoring signals in a communications system in which data communications signals are transferred at a given data rate so that these control and monitoring signals may be detected in a relatively simple manner.

This is achieved according to the invention by a method wherein the data rate of data communications signals in a communications network is modulated in accordance with relatively low frequency information, in the form of control and monitoring signals, so that the contribution of the modulation to the total variation of the data rate in the network does not exceed a specified level.

It will be expedient that said modulation of the data rate is performed so that the frequency components caused by the modulation are positioned in a frequency band, as stated in claim 2, in which the data channels in the communications network are disturbed as little as possible.

If, as stated in claim 3, this frequency band is placed where the variation in the data rate (jitter) is already low, the relatively low frequency data information, in the form of control and monitoring signals, may have a maximum dynamic range.

In an SDH network (Synchronous Digital Hierarchy), it will be particularly expedient to place said frequency band between 500 Hz and 3 kHz. This is stated in claim 4.

An expedient embodiment is obtained if, as stated in claim 5, it is possible to embed several channels in the

relatively low frequency data information. Several repeaters may hereby be controlled independently of each other.

A first expedient embodiment for the embedding of several channels in the relatively low frequency data information is stated in claim 6, in which said channels are obtained by coding the relatively low frequency data information.

Another expedient embodiment for the embedding of several channels in the relatively low frequency data information is stated in claim 7, in which said channels are obtained by allocating to each channel a frequency band in the modulated signal.

Further, as stated in claim 8, it is expedient that the relatively low frequency data information is used for controlling a receiver, e.g. in the form of an optical repeater.

An expedient embodiment is obtained, e.g. as stated in claim 9, by modifying a known transmitter circuit so that the relatively low frequency data information may contribute to the control of the output signal of a multiplex circuit, thereby generating a variation in the output data rate within a specific range.

A particularly expedient embodiment is obtained if, e.g. as stated in claim 10, the relatively low frequency data information contributes to the control of an oscillator connected to control said multiplex circuit.

The invention will now be described more fully below with reference to the drawing, in which

fig. 1 shows a part of an optical communications system in which the invention may be applied,

fig. 2 shows a transmitter in which the invention may be applied,

fig. 3 shows a transmitter adapted to transmit ordinary communications signals and control/monitoring signals according to the invention,

fig. 4 shows an electrical demodulator in an optical amplifier,

fig. 5 shows jitter as a function of frequency, where the curve 33 is the jitter which a receiver must be capable of tolerating as a minimum and a transmitter may generate as a maximum, while the curve 34 is an example of the probable maximum jitter in a network in which the invention is not applied,

fig. 6 shows that several receivers are capable of receiving control and monitoring signals.

Fig. 1 shows a part of an optical communications system in which the invention may be applied. A transmitter 1 transmits communications signals, e.g. telecommunications signals, in the form of optical signals into an optical fibre 7. In a communications network, the nodes are network elements. Various forms of data switching and exchange may take place in network elements. If the distance to the network element in which the communications signals are to be detected, is suitably long, the optical signals will be subjected to such a strong attenuation that it is necessary to amplify them en route, so that the communications signals may be detected correctly in the receiver. One or more so-called repeaters 2 are

therefore inserted into the transmission path between two network elements, the purpose of the repeaters being to amplify arriving signals and to pass them further on in the network. The repeaters may be implemented both as electrical and optical amplifiers or as a hybrid thereof.

Optical repeaters are prior art and will not be described in detail. However, it is noted that optical repeaters are based on performing the amplification of the optical signals in an optical fibre doped with a fluorescent material, e.g. the earth Erbium. The supply of energy to the doped fibre takes place by coupling optical pump power into the fibre at a wavelength which does not coincide with the signals to be amplified. For a repeater 2 to be controlled, it is necessary, however, to introduce a plurality of electrical circuits. The amplifier 2 in fig. 1 therefore comprises e.g. an optical power divider 4 connected to an optical/electrical converter 5 so that the optical signal may be monitored electrically. It should be noted that the order of the power divider 4 and the amplifier 3 may be reversed, of course. The circuit 6 is a circuit in which it is possible to control the repeater 2 on the basis of an electrical representation of the optical communications signals. If some form of systematic variation in the signal ransmitted via the optical fibre is introduced into the transmitter 1, it is possible to detect this variation in the circuit 6 on the basis of an electrical signal generated by the optical/electrical converter 5.

Fig. 2 shows a network element in which the invention may be applied. More or less sophisticated processing of data will take place in such a network element, causing the data, which have been subjected to processing, to arrive in an uneven flow. In a network element 10 it is thus well-known to have a buffer 12 interposed between a proc-

essing unit 11 and an output module 14, e.g. in the form of an electrical/optical converter. Output of data from the buffer 12 is controlled by a phase-locked loop. This phase-locked loop consists of a phase/frequency detector 15 which measures the difference between a local synchronization clock LS and an output clock signal for the buffer 12. The output signal from the phase/frequency detector 15 is filtered in the filter 16, and the filtered signal, in the form of a control signal, controls the output frequency of the oscillator 17. This results in a jitter-free data rate out of the network element 10. Since the circuit in fig. 2 comprising a buffer and a phase-locked loop is assumed to be known to a skilled person, only the principle is illustrated.

The ability to suppress fluctuations in the data rate caused by the internal processing functions of the network depends primarily on the size of the buffer and the bandwidth of the loop. The bandwidth of this phase-locked loop is determined such that it suppresses fast variations in the data flow, and so that it permits relatively small and slow variations in the data flow to pass out of the transmitter. The principle is specified in various standards. The purpose of this is to make some standardized requirements with respect to the variation which a network element receiving transmission data must be capable of tolerating as a minimum. An example of a specification of the variation which must be tolerated in a network element receiving transmission data, is shown in fig. 5 as curve 33. The variation measured in unit intervals is shown as a function of the frequency F. A unit interval corresponds to a bit period.

Since a communications system e.g. based on the SDH standard is associated with a plurality of characteristic frequencies, e.g. frame and bit rates, a data processing

system will cause variations (jitter) with several spectral components. This spectral distribution depends on the network configuration concerned, of course, but may be approximated to a sufficient extent to be utilized in the invention. This is illustrated in fig. 5 curve 34, based on an SDH network. A characteristic bulge occurs in the spectral distribution at about 10 kHz and at DC. The hatched area 35 in fig. 5 indicates that a contribution to the variation already present in the network may be introduced in a frequency band between F_1 and F_2 (about 500 Hz and 3 kHz). This variation may be introduced in a dynamic range D_1 to D_2 having the size of about 0.8 UI. The dynamic range between D_2 and the curve 33 in fig. 5 shows that the system has a certain tolerance with respect to the specifications in practice.

The above-mentioned variation in the dynamic range D_1 to D_2 may be introduced e.g. by implementing a circuit in a network element as shown in fig. 3. Fig. 3 shows a network element adapted to transmit ordinary communications signals and control/monitoring signals according to the invention. The transmitter 20 is different from the transmitter 10, as the phase-locked loop is modified so that it may be modulated with signals according to the invention. This may be achieved e.g. by adding a new control signal, caused by a control or monitoring signal, to the control signal from the filter 26. It is thus the sum of the two control signals, generated by the summation element 28, which is used for controlling the oscillator 27. The new control signal from the modulator 29 must necessarily be so fast that the control signal from the filter 26 cannot compensate the phase error caused by the new control signal.

The modulator 29 is based on prior art and is arranged such that a control and monitoring signal, DATA, is con-

verted by means of a clock signal, CLK, into the new control signal which contributes to the modulation of the oscillator 27. It is hereby possible to transmit the signal DATA, which may be detected in a relatively simple manner, while transmitting e.g. teleinformation in the mentioned complicated frame structure.

The method of transferring control and monitoring signals, as described above, may be extended to transfer control and monitoring signals for several receivers. This may be implemented in an embodiment by addressing the individual receivers with a coded signal. This addressing and coding may take place by using a data protocol which is known to both transmitter and receiver.

Alternatively, control and monitoring signals may be transferred to several receivers by using frequency multiplexing so that each receiver is dedicated to a predetermined frequency band in which the control and monitoring signals are transmitted.

P a t e n t   C l a i m s :

1. A method of transferring relatively low frequency data information on a data channel for relatively high frequency data transmission, c h a r a c t e r i z e d in that the data rate of the relatively high frequency data channel is modulated in accordance with the low frequency data information so that the phase variation generated thereby is within a range which is defined upwardly by a predetermined value and defined downwardly by the phase variation which occurs in the data channel at an unmodulated data rate.

2. A method according to claim 1, c h a r a c t e r i z e d in that the modulation is controlled such that frequency components occur in a predetermined frequency band.

3. A method according to claim 2, c h a r a c t e r i z e d in that the frequency band is selected as a band in which the jitter swing in the data channel at an unmodulated data transmission is relatively low.

4. A method according to claim 3, c h a r a c t e r i z e d in that the frequency band is between 500 Hz and 3 kHz.

5. A method according to claim 1, c h a r a c t e r i z e d in that the relatively low frequency data information contains several data channels.

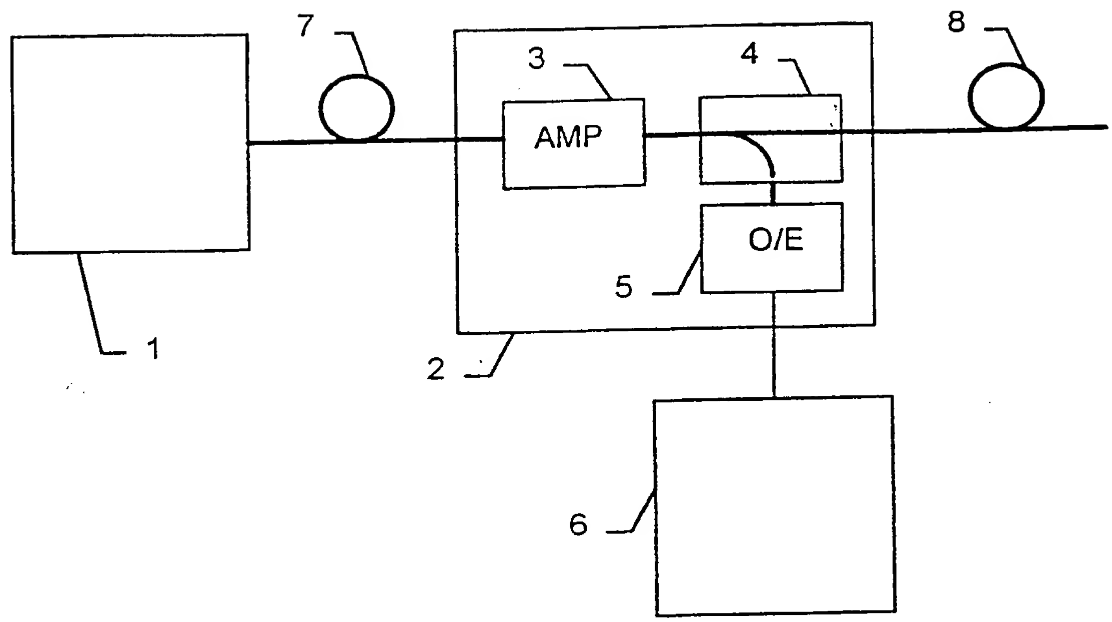
6. A method according to claim 5, c h a r a c t e r i z e d in that said channels are obtained by coding the relatively low frequency data information.

7. A method according to claim 5 or 6, c h a r a c - t e r i z e d in that said channels are modulated in their respective frequency bands in accordance with the associated relatively low frequency data signals.

8. A method according to claim 1, wherein the relatively low frequency modulation is detected in a receiver, c h a r a c t e r i z e d in that the detected low frequency data signal is used for controlling the receiver.

9. A circuit for transmitting relatively low frequency data information on a data channel for high frequency data transmission and comprising a multiplex circuit (23) as well as a circuit (22, 25, 26, 27, 28) to generate a control signal for the multiplex circuit to transmit the relatively high frequency data transmission, c h a r - a c t e r i z e d in that the control circuit is adapted to receive the relatively low frequency data information and to control the output signal of the multiplex circuit so as to generate a phase variation in the output signal within a range which is defined upwardly by a predetermined value and defined downwardly by the phase variation which occurs in the data channel at an unmodulated data rate.

10. A circuit according to claim 9, c h a r a c t e r - i z e d in that the control circuit comprises an oscillator (27) which is controlled by a phase/frequency detector (25) and by a modulation signal generated in response to the relatively low frequency data information.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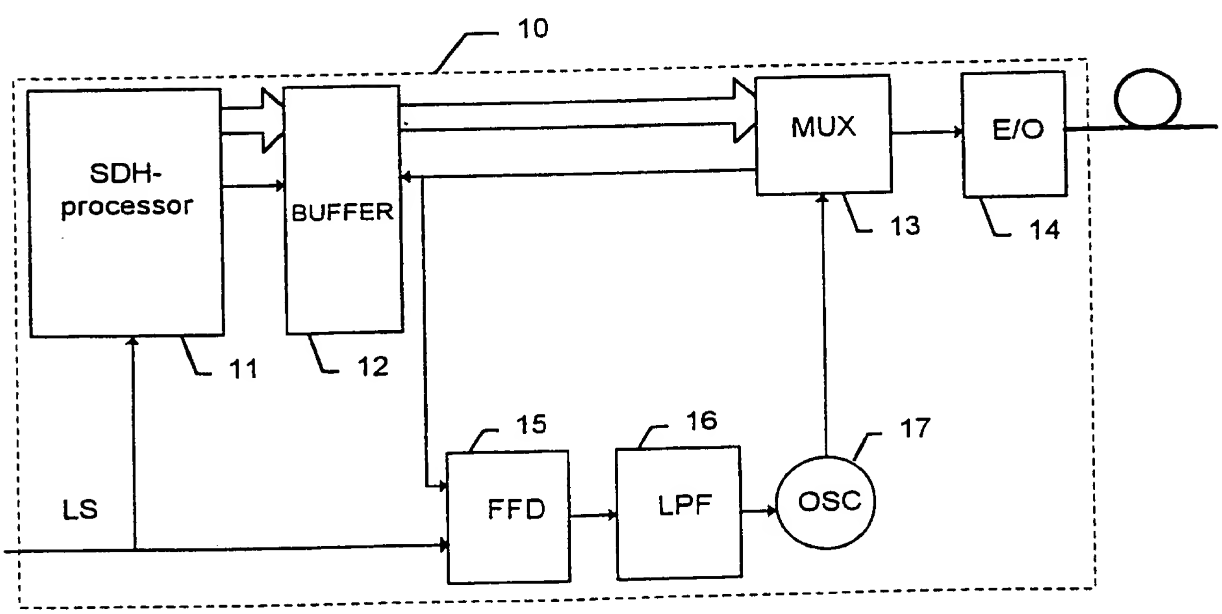
2
6

Fig. 1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17
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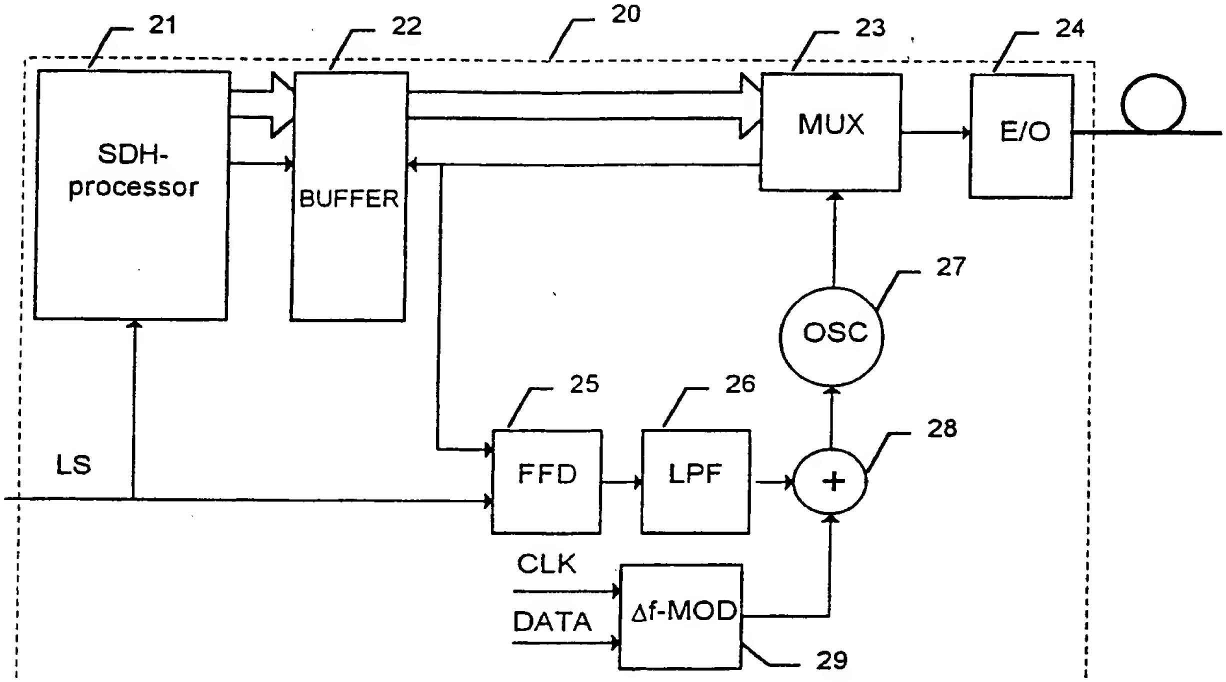
LPF
OSC
LS

Fig. 2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processor
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LS
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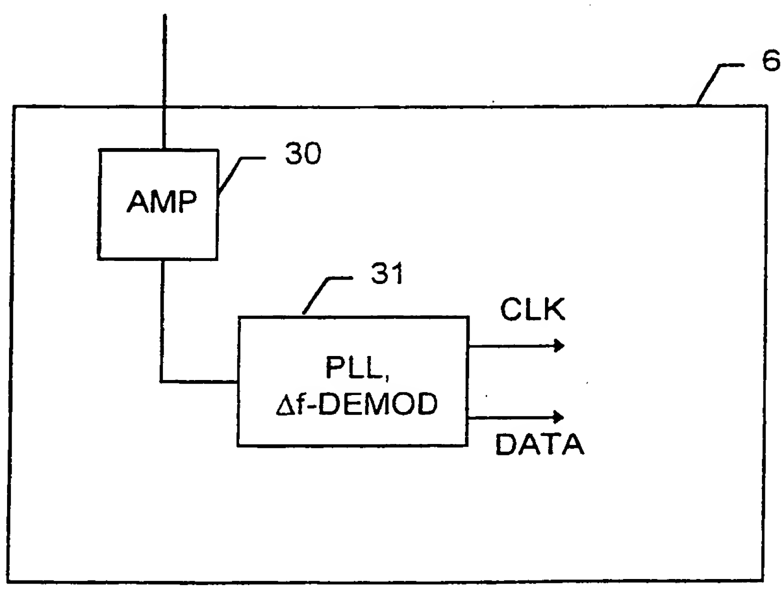
+
CLK
DATA
Δf-MOD
29

Fig. 3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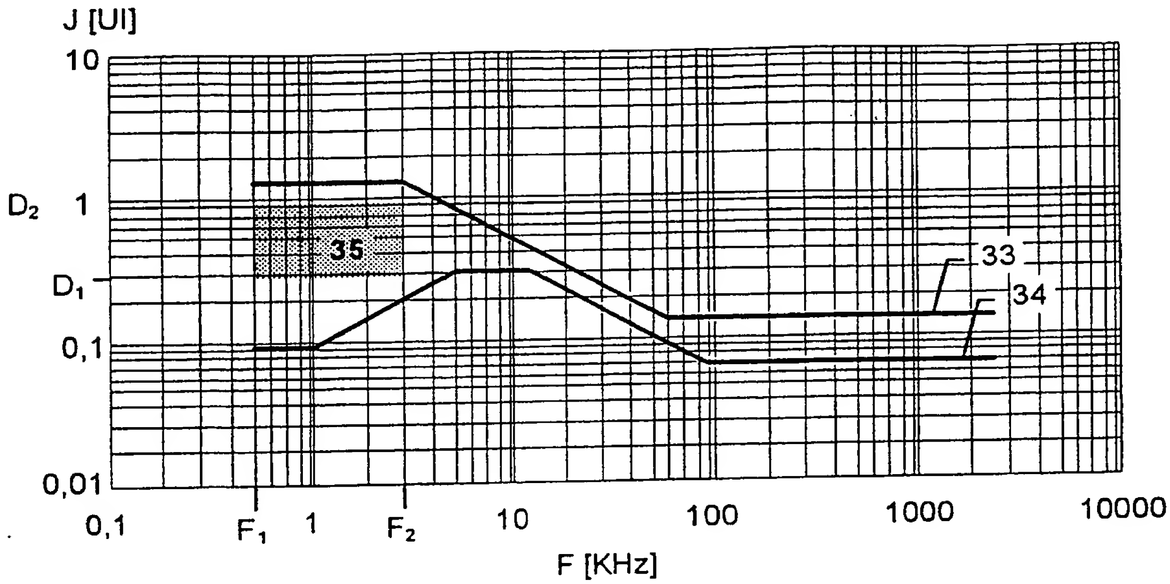
Δf-DEMOD
DATA

Fig. 4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D1
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0,1
F1
1
F2
10
100
1000
10000
F [KHz]
35
33
34

Fig. 5

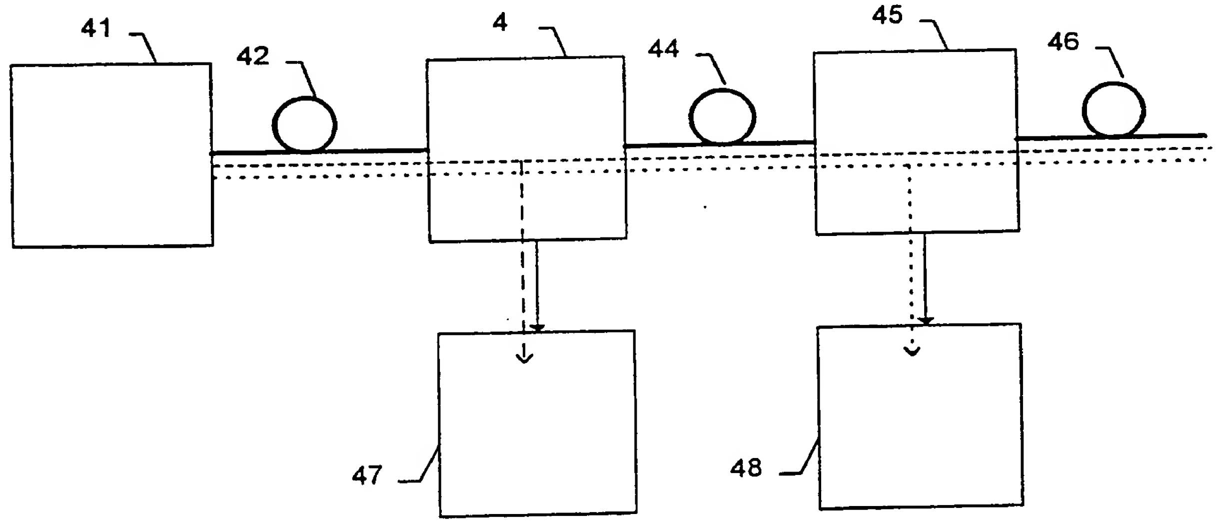
41
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Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK 97/00592

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H03K 7/10, H03K 9/10, H04B 14/02, H04J 9/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04L, H04B, H03K, H04J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US 46770608 A (GUNNAR S.FORSBERG), 30 June 1987 (30.06.87), column 2, line 42 - column 3, line 16, abstract --	1-10
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
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